DOCUMENT RESUME

ED 396 918 SE 058 410

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TITLE A Comparison of Science Laboratory Classrooms in Asia, Australia, South Pacific and USA: An International Study.
PUB DATE Apr 96
NOTE 11p.; Paper presented at the Annual Meeting of the American Educational Research Association (New York, NY, April 8-12, 1996).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Classroom Environment; Comparative Analysis; Foreign Countries; High Schools; International Studies; Science Curriculum; *Science Laboratories; *Secondary School Students; *Student Attitudes; Surveys; Teaching Methods

ABSTRACT

This study attempted to compare the science laboratory learning environments of secondary schools across both developed and developing countries (Australia, Brunei, Cook Islands, Fiji, Papua New Guinea, Singapore, Solomon Islands, Tonga, Tuvalu, United States, Vanuatu, and Western Samoa). The study used a version of the Science Laboratory Learning Environment Inventory that had been previously validated for use in both developing and developed country contexts. Analysis of data generated found surprisingly similar science laboratory learning environments across most high schools throughout the countries with one of the environment scales, Open-endedness, as the least favorable scale. Overall students' attitude towards science were very favorable with boys tending to have a more favorable attitude than girls. The study suggests that global changes in general teaching practice has had little influence on science laboratory teaching practices and that science teaching, although to some extent culturally bound, also has to a large degree an "ethos" and methodology of its own, with an inherent resistance to change. Contains 27 references. (Author)

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ED 396 918

A Comparison of Science Laboratory Classrooms in Asia, Australia, South Pacific and USA: An International Study

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A paper presented at the Annual Meeting of American Educational Research Association, New York, April 8-12.

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Abstract

This study attempted to compare the science laboratory learning environments of secondary schools across both developed and developing countries (Australia, Brunei, Cook Islands, Fiji, Papua New Guinea, Singapore, Solomon Islands, Tonga, Tuvalu, USA, Vanuatu and Western Samoa). The study used a version of the Science Laboratory Learning Environment Inventory that had been previously validated for use in both developing and developed country contexts. Analysis of data generated found surprisingly similar science laboratory learning environments across most high schools throughout the countries with one of the environment scales, Open-endedness, as the least favourable scale. Overall students' attitude towards science were very favourable with boys tending to have a more favourable attitude than girls. The study suggests that global changes in general teaching practice has had little influence on science laboratory teaching practices and that science teaching, although to some extent culturally bound, also has to a large degree an "ethos" and methodology of its own, with an inherent inbuilt resistance to change.

BACKGROUND AND RATIONALE

Countries such as the United States and Australia are increasingly becoming more concerned about the "standards" of their education systems. Because the study of science is perceived as an essential element of the curriculum (Dare, 1990; West, 1988) then one of the major priorities in the process to reflect on the educational "standards" of high schools is to examine the effectiveness of one of the main components, namely, science teaching. As developing countries spend 22 times less on instructional material per pupil than do developed countries (Caillods & Postlethwaite, 1989), it was thought important to compare the science classrooms across such countries as Australia and the United States with some developing countries in order to identify the current state of science teaching practices across these countries. What similarities or differences exist between science classrooms of Australia, USA and the developing countries of Asia and the South Pacific, given such a disparity in resourcing levels?

Research has shown that there has been considerable disagreement over the value of the science laboratory classroom (Lynch, 1986; Tamir, 1989; Lehman, 1989). One of the major factors that appear to affect student learning is the classroom psychosocial environment (Fraser, 1989). There is substantial evidence which indicates that teachers do make a more substantial difference to student achievement, attitude and motivation in developing countries than what would be expected to find in developed countries (Brophy & Good, 1986; Twoli & Power, 1989). However, there has been comparatively little research into teaching practices in science (Roadrangka & Yeany, 1982; Harpole, 1987) in these countries. Even less research has been conducted into the state of science laboratory teaching activities in developing countries. There is very little published research into the current teaching practices in Asian and South Pacific science laboratory classrooms and consequently there has been virtually no comparison of Asian, South Pacific, USA and Australian science classrooms.

The study reported here attempted to fill some of this dearth of research by comparing the learning environments of Australian, USA, South Pacific and Asian science laboratory classrooms.

METHODOLOGY

The study reported here utilised quantitative (questionnaire & survey instruments) methods. The South Pacific (SP) countries studied included Cook Islands, Fiji, Papua New Guinea, Solomon Islands, Tonga, Tuvalu, Vanuatu and Western Samoa. The Asian countries studied were Singapore and Brunei. Data from Australia and the USA were also included.

A questionnaire administered to each sample attempted to examine:

i) students' and their science teachers' perceptions of the science laboratory classroom learning environment; and
ii) students' attitudes towards science.

This study compares Australian and USA science classrooms with those in the developing countries of the South Pacific and Asia on students' perceptions of the science laboratory classroom learning environment. Data about the science laboratory learning environment was collected using the SLEI, the Science Learning Environment Inventory (Giddings & Fraser, 1990). Data about students' attitudes towards science was obtained using a modified form of the Test of Science-Related Attitudes (Fraser,

1981). Both of these instruments were adapted for use in South Pacific countries where English is a second language for many students (Waldrip & Giddings, 1993).

The Sample

The data in this study forms part of an ongoing data collection within Australia, Asia, United States and South Pacific countries. The student sample consisted of Year 11 students in all countries except for Australia and Papua New Guinea which involved Year 10 students. As most of these South Pacific countries are small nations, it was not unexpected to have some whole country samples, for example, Tuvalu and Vanuatu. The data which forms the basis of these results were obtained chiefly from the SLEI and from the teacher and student versions of the classroom teaching activities questionnaires, supplemented by lesson observations and other anecdotal evidence.

SCIENCE LABORATORY LEARNING ENVIRONMENTS

The physical facilities are only one aspect of the environment of a science laboratory classroom, the learning environment is another important aspect. The five scale version of the SLEI, the Science Laboratory Environment Inventory used in this study had been previously validated by Giddings, Fraser and McRobbie (1992). The Australian sample involved 1594 students in 52 schools. The South Pacific sample involved 3637 students in 58 schools. The Asian sample involved 1670 students in 65 schools (Wong, 1994). The USA sample included 885 students in 45 classes. The USA data was obtained during the initial validation of SLEI (Giddings and Fraser, 1990). Table 1 clarifies the meaning of each of the five scales in SLEI by providing a scale description and sample item.

Table 1: Descriptive Information for Each Scale in Personalised Science Laboratory Environment Instrument (SLEI) Scales

Scale Name	Description	Sample Item
Student Cohesiveness	Extent to which students know, help and are supportive of one another.	I work well with others during experiments.
Open-Endedness	Extent to which the laboratory activities emphasize an open- ended, divergent approach to experimentation.	I can do experiments by myself
Integration	Extent to which the laboratory activities are integrated with non- laboratory and theory classes.	What I learn in class doesn't help me to do the experiments.
Rule Clarity	Extent to which behaviour in the laboratory is guided by formal rules.	I have certain rules to obey in the science laboratory.
Material Environment	Extent to which the laboratory equipment and materials are adequate.	Laboratory equipment is in poor working order

Table 2 contains the internal consistency (alpha reliability coefficient) data for the SLEI for when the sample is school or individually based. It shows that for the sample of students as individuals, the alpha coefficient ranged from 0.63 to 0.85 for Australian schools, 0.74 to 0.84 for USA schools, 0.41 to 0.72 for Asian schools and 0.48 to 0.63 for South Pacific schools, and on a school by school basis, the alpha coefficient ranged from 0.78 to 0.94 for Australian schools, 0.84 to 0.96 for USA schools, 0.54 to 0.87 for Asian schools and 0.57 to 0.82 for SP schools. It is not surprising to note that the alpha

reliability was consistently greater with the school being the unit of analysis rather than with the individual being the unit of analysis. This is because the aggregation that occurs when the school mean is the unit of analysis, results in the variance being less and the consequential improvement in reliability.

Table 2: Item Mean and Cronbach Alpha Reliability for Australian, USA, Asian and South Pacific Science Classrooms

Scale		Individual Mean				Class Mean			
		Aust	USA	Asia	SP	Aust	USA	Asia	SP*
Student Cohesiveness	Item Mean	3.70	3.90	3.85	4.20				
	Reliability	.78	.92	.68	.49	.80	.81	0.64	.59
Open-Endedness	Item Mean	2.48	2.52	2.34	2.30				
	Reliability	.71	.84	.41	.48	.80	.75	.54	.57
Integration	Item Mean	3.93	3.90	3.89	4.47				
	Reliability	.86	.96	.69	.48	.91	.84	.87	.73
Rule Clarity	Item Mean	3.53	3.80	3.83	4.47				
	Reliability	.74	.92	.63	.58	.76	.76	.84	.77
Material Environment	Item Mean	3.73	3.94	3.51	4.19				
	Reliability	.76	.88	.72	.57	.74	.74	.82	.82
	Sample Size	1594	885	1817	3637	52	45	65	58

* In South Pacific countries, the school mean was provided instead of the class mean

The reliability data in Table 2 suggests that the refined version of each SLEI scale has acceptable reliability, especially for scales containing a relatively small number of items when either the individual student or the school is used as the unit of analysis. As expected, Cronbach's alpha reliability was higher when the unit of analysis was the school instead of the individual because of the effects of aggregation. The overall reliability of SLEI scales was measured by determining the reliability of the scales when the unit of analysis was the individual (α = 0.52 (SP), = 0.77 (Aust), = 0.63 (Asia), = 0.90 (USA)) and when the school mean was the unit of analysis (α= 0.69 (SP), = 0.80 (Aust), = 0.74 (Asia), = 0.78 (USA)). Data about discriminate validity was generated by using the mean correlation of a scale with the other scales on both an individual and school basis. Comparable results were obtained in both cases. Comparing school and individual perceptions, there appears to be no significant differences. The mean correlation shows that each scale is largely independent of each other and so are measuring different entities.

A desirable characteristic of the SLEI is that it is capable of differentiating between perceptions of students in different schools or classes. This characteristic was explored by analysis using one-way ANOVA, with school membership as the main effect

and using the individual as the unit of analysis. The results indicated that each scale differentiated significantly ($p<0.001$) between schools.

Students' scale item means and science teachers' scale item means were plotted in Figure 1. The pattern of this plot was consistent with past research (Fraser, 1982, 1986; Fraser, Giddings and McRobbie, 1991). Figure 1 showed that in all regions that open-endedness was the least favourable SLEI scale. As well, Figure 1 showed that the SLEI scale means were similar for both students and science teachers across all regions. However, there were differences. Figure 1 indicated that South Pacific students perceived a slightly more favourable laboratory classroom than the one perceived by teachers. Only the Material Environment showed that the difference in perceptions were significant, South Pacific students perceiving a more favourable environment than their teachers. Compared to their teachers, Asian students perceived a less favourable perception of Open-endedness but had a more favourable perception of Rule Clarity and Material Environment. The Australian and USA teachers, as reported previously (Giddings & Fraser, 1992), had a generally more favourable perception of their learning environment than their students.

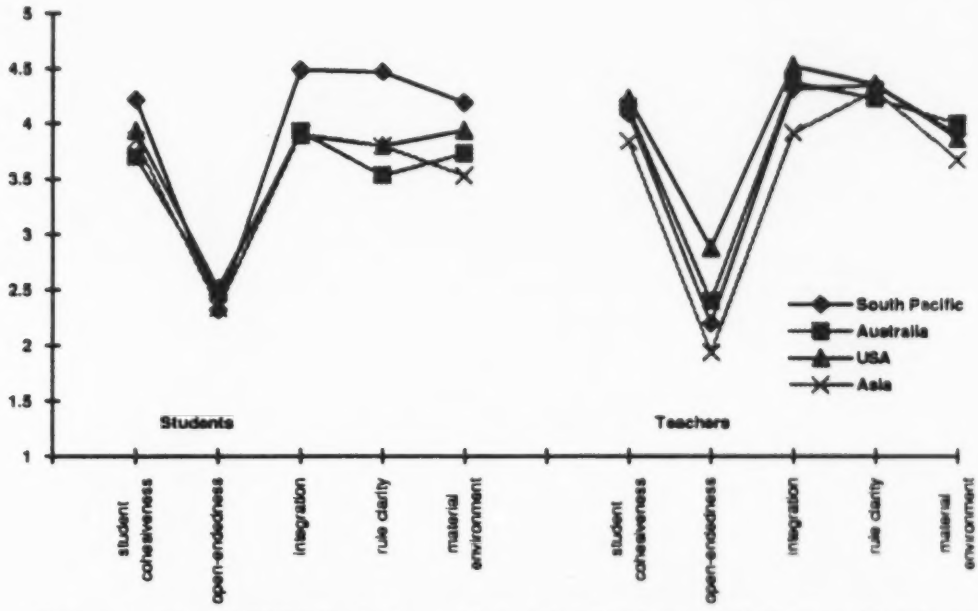

Figure 1: Plot of SLEI Scale Item Means for Students and Science Teachers

However, it is important to note that South Pacific students perceived a more favourable learning environment than did their Asian, Australian and USA counterparts. In contrast, Asian teachers had comparably overall lower favourable perception of their learning environment compared to other teachers. Except for Rule Clarity, Asian teachers perceived a less favourable learning environment than did their Asian, Australian and USA counterparts. Australian and USA teachers tended to perceive more favourably the scales of Student Cohesiveness and Open-Endedness than did the Asian and South Pacific teachers.

Male students scale means and female students scale means were plotted in Figure 2. The pattern was similar to the results of previous research in both developed and developing countries (Fraser, 1982, 1986; Fraser, Giddings & McRobbie, 1991, 1992; Giddings & Waldrip, 1993) in that Open-endedness was the least favourable SLEI scale. Considering the size of some samples, there was a strong similarity between each learning environment scales.

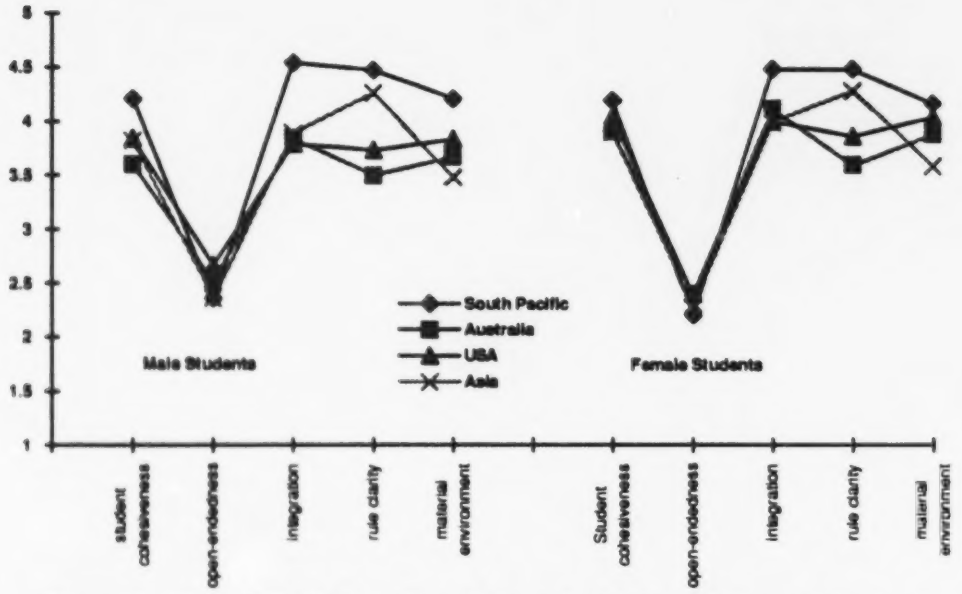

Figure 2. Plot of SLEI Scale Item Means for Male and Female Students

South Pacific male students perceived their learning environment generally more favourable than other students. Overall, male USA and Australian students perceived a less favourable learning environment than the other students. However, in the South Pacific countries, female students perceived Integration and Rule Clarity slightly more favourably whereas male students perceived student cohesiveness, open-endedness and material environment in a more favourable light. There was no significant difference between male and female South Pacific students' perceptions of the dimensions of the SLEI. With the Australian and USA students, females perceived Student Cohesiveness, Integration and Material Environment more favourably. Asian male students perceived less favourable Integration than did their female counterparts. Overall, the learning environment profile was strikingly similar for all countries studied. When there were differences, females were more likely to perceive a more favourable learning environment.

STUDENTS' ATTITUDES TOWARDS SCIENCE

Students' attitudes towards science was compiled using the aggregate score representing students' response to a simple 17-item Likert-type questionnaire assessed opinions about the science laboratory. This questionnaire was entitled Attitudes. The Attitudes questionnaire had a reliability of 0.62 based on 2819 students' responses. Interestingly, students from all South Pacific countries had similar students' attitudes towards science which were more favourable than those of the Australian and USA

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sample. Similar to many previous studies (Gardner, 1975; Schibeci, 1984), females in this study had a less favourable attitude towards science than did the males.

DISCUSSION

The adaptation of SLEI to the developing South Pacific countries, Asian, Australian and USA context, produced a valid, reliable instrument that had adequate discriminant validity and was able to distinguish between different schools. In all countries studied, the science learning environment was viewed favourably overall but there was a low perception on the open-endedness scale. Both students and teachers perceived SLEI scales similarly but South Pacific students perceived Material Environment more favourably. South Pacific students perceived a more favourable learning environment than did their Asian, Australian and USA counterparts. Except for Rule Clarity, Asian teachers perceived a less favourable learning environment than did their Asian, Australian and USA counterparts. Australian and USA teachers tended to perceive more favourably the scales of Student Cohesiveness and Open-Endedness than did Asian and South Pacific teachers. This study failed to find any significant differences between perceptions of male and female South Pacific students except for Open-endedness where male students had a more favourable perception. Generally Asian teachers perceived a less favourable learning environment than did their students. Concerning students' attitudes towards science, male students in all countries had a more favourable attitude towards science than did their female stuedent counterparts.

These findings seem to suggest that science teachers remain largely unconvinced as to the value of some of the practical activities occuring in science laboratory classroom. Despite USA and Australian science teachers having received more years of teacher training and a higher perceived level of equipment, they all had classes with similar low levels of Open-Endedness to that of the Asian and South Pacific teachers. It could be argued that in spite of the supposed inroads by constructivists into teaching pedagogy and teacher training, constructivism has made very little difference to the teaching practices of the USA and Australian science teacher. It could also be claimed that both USA and Australian science classrooms have similar characteristics to South Pacific and Asian classrooms which are fairly unlikely to have been exposed to or influenced by the theories of constructivism. In fact there may have been insufficient lead time for the implementation of constructivism to impact on teaching pedagogy.

Another interpretation of the results of this study may be that science teaching in general, and laboratory teaching in particular, is so complex an unde-taking that an examination of teaching activities and laboratory learning environment is unable to reveal the differences that may exist between developing and developed countries. It may also be the case that science teaching has its own cross-cultural base that results in most science teachers adopting similar teaching practices. This suggestion is partially supported by the strong similarities in learning environments profiles of laboratory teaching across all countries. However, a strong similarity in teaching activities across these countries may not surprising given that all the countries in the sample all have a strong British educational heritage. Certainly, the Asian countries and Australia studied have a education system that is largely modelled on the British system.

Finally, the study suggests that global changes in general teaching practice has had little influence on science laboratory teaching practices and that science teaching although to some extent culturally bound, also has to a large degree an "ethos" and methodology of its own, with an inherent inbuilt resistance to change. Hence one can

argue that science teaching has its own culture that is more persuasive than the context in which it is situated.

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